
High Power Microwave Research, Atmospheric Plasma Phenomena, Ultra-Wideband Propagation and Generation

William Prather and Dr. David W. Scholfield

Principal Investigator: Prof John M. Gahl

**University of New Mexico
Albuquerque, New Mexico 87131**

September 2001

Final Report

Approved for Public Release; distribution is unlimited.



**AIR FORCE RESEARCH LABORATORY
Directed Energy Directorate
3550 Aberdeen Ave SE
AIR FORCE MATERIEL COMMAND
KIRTLAND AIR FORCE BASE, NM 87117-5776**

20040414 040

AFRL-DE-TR-2001-1061

Using Government drawings, specifications, or other data included in this document for any purpose other than Government procurement does not in any way obligate the U.S. Government. The fact that the Government formulated or supplied the drawings, specifications, or other data, does not license the holder or any other person or corporation; or convey any rights or permission to manufacture, use, or sell any patented invention that may relate to them.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

If you change your address, wish to be removed from this mailing list, or your organization no longer employs the addressee, please notify AFRL/DEHP, 3550 Aberdeen Ave SE, Kirtland AFB, NM 87117-5776.

Do not return copies of this report unless contractual obligations or notice on a specific document requires its return.

This report has been approved for publication.

//signed//

WILLIAM PRATHER, DR-IV
Project Manager

//signed//

REBECCA N. SEEGER, Col, USAF
Chief, High Power Microwave Division

//signed//

L. BRUCE SIMPSON, SES
Director, Directed Energy Directorate

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.					
1. REPORT DATE (DD-MM-YYYY) 30-09-2001		2. REPORT TYPE Final Report		3. DATES COVERED (From - To) 9/1998- 9/2001	
4. TITLE AND SUBTITLE High Power Microwave Research, Atmospheric Plasma Phenomena, Ultra-Wideband Propagation and Generation				5a. CONTRACT NUMBER F29601-98-K-0185	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER 62601F	
6. AUTHOR(S) William Prather, Dr. David W. Scholfield * Prof John M. Gahl				5d. PROJECT NUMBER 4867	
				5e. TASK NUMBER HJ	
				5f. WORK UNIT NUMBER 01	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) * University of New Mexico Albuquerque, New Mexico 87131				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFRL/DEHP 3550 Aberdeen Avenue SE Kirtland AFB NM 87117-5776				10. SPONSOR/MONITOR'S ACRONYM(S) AFRL/DEHP	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) AFRL-DE-TR-2001-1061	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for Public Release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT The primary objectives of this effort were to investigate gas breakdown, plasma antennas, and laser induced plasmas in the atmosphere. The contractor investigated the electrical breakdown of different types of gas under very fast transient voltage excitation. The research addresses different types of gas under different conditions of pressure, temperature, and electrical field stress as expressed on a Paschen curve. The contractor also investigated the feasibility of generating and shaping conducting plasma to be used as an antenna and generating a conducting path in the atmosphere using a high power laser.					
15. SUBJECT TERMS gas breakdown, plasma antennas, laser induced plasma, conducting plasma, antenna, high power microwave					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			William Prather
Unclassified	Unclassified	Unclassified	SAR	10	19b. TELEPHONE NUMBER (include area code) 505-846-0416

[This page intentionally left blank.]

TABLE OF CONTENTS

I.	Objective.....	1
II.	Scope.....	1
III.	Background.....	1
IV.	Technical Activities.....	2
V.	Conclusion.....	2

[This page intentionally left blank.]

GOVERNMENT SUMMARY

I. Objective:

The primary objectives of this effort were to investigate gas breakdown, plasma antennas, and laser induced plasmas in the atmosphere.

II. Scope:

Although a great deal of data exists on gas breakdown, there are gaps in the published data when dealing with high electric field stresses and very fast risetimes. The scope of this effort was to fill in the gaps with real data. This report is a compilation of articles discussing the findings from the project.

III. Background:

The contractor investigated the electrical breakdown of different types of gas under very fast transient voltage excitation. The contractor developed theoretical models of gas breakdown characteristics and their calculations were compared to laboratory measurements. Subsequently, the calculations were compared to measurements. The research addresses different types of gas under different conditions of pressure, temperature, and electrical field stress as expressed on a Paschen curve. Measurements were made using the H-2 high voltage coaxial source. The contractor also investigated the feasibility of generating and shaping conducting plasma to be used as an antenna and generating a conducting path in the atmosphere using a high power laser. One test set-up was built and measured. The physics involved in the ionization of atmospheric air by an intense laser were investigated, starting with small (mm) sized gaps.

IV. Technical Activities

List of the relevant publications produced under this contract:

1. D.W. Scholfield, J.M. Gahl, and N. Shimomura, "Effective electric field for an arbitrary electromagnetic pulse," *IEEE Transactions on Plasma Science*, Volume 27, Issue 2, April 1999, pp. 628-632.
2. N. Shimomura, D.W. Scholfield, J.M. Gahl, and J. Lester, "Investigation of intense electromagnetic transient phenomenon and Paschen curves for hydrogen and helium in subnanosecond regime," *IEEE Transactions on Plasma Science* Vol. 28, No. 3, June 2000, pp. 496-501.
3. D.W. Scholfield, J.M. Gahl, and N. Shimomura, "Columnar focal lens," *Review of Scientific Instruments*, Vol. 70, No. 5, May 1999, p. 2495-9.
4. William M. White, "Investigation of the Characteristics of Atmospheric Laser Induced Plasmas," Master's Thesis, Dept of Electrical Engineering, The University of New Mexico, Albuquerque, New Mexico, December 2000.
5. J.M. Gahl, J.L. Koriath, W.M. White, and D.W. Scholfield, "Field Emission Peaking Switch Studies," *Proceedings of the 12th International Pulsed Power Conference*, Monterey, CA, June 1999.

V. Conclusion

As a result of this contract, much of the parameter space not covered by published data has been filled in for the benefit of all researchers. The physics involved in the ionization of atmospheric air by an intense laser demonstrates the ionization of air over a small gap and also reveals some of the physical parameters that will come into play when the gap is made much larger. This investigation is very enlightening and will lay the groundwork for future investigators.

Distribution List

DTIC/OCP 8725 John J. Kingman Rd, Suite 0944 Ft Belvoir, VA 22060-6218	1 cy
AFRL/VSIL Kirtland AFB, NM 87117-5776	2 cys
AFRL/VSIIH Kirtland AFB, NM 87117-5776	1 cy
AFRL/DE/Dr. William L. Baker Kirtland AFB, NM 87117-5776	1 cy
Official Record Copy AFRL/DEHP/William Prather	2 cys